ESL-IC-08-10-

Improving indoor air quality improves the performance of office work and schoolwork

Pawel Wargocki
International Centre for Indoor Environment and Energy
Department of Civil Engineering
Technical University of Denmark
(www.ie.dtu.dk)

Proceedings of the Eighth International Conference for Enhanced Building Operations, Berlin, Germany, October 20-22, 20

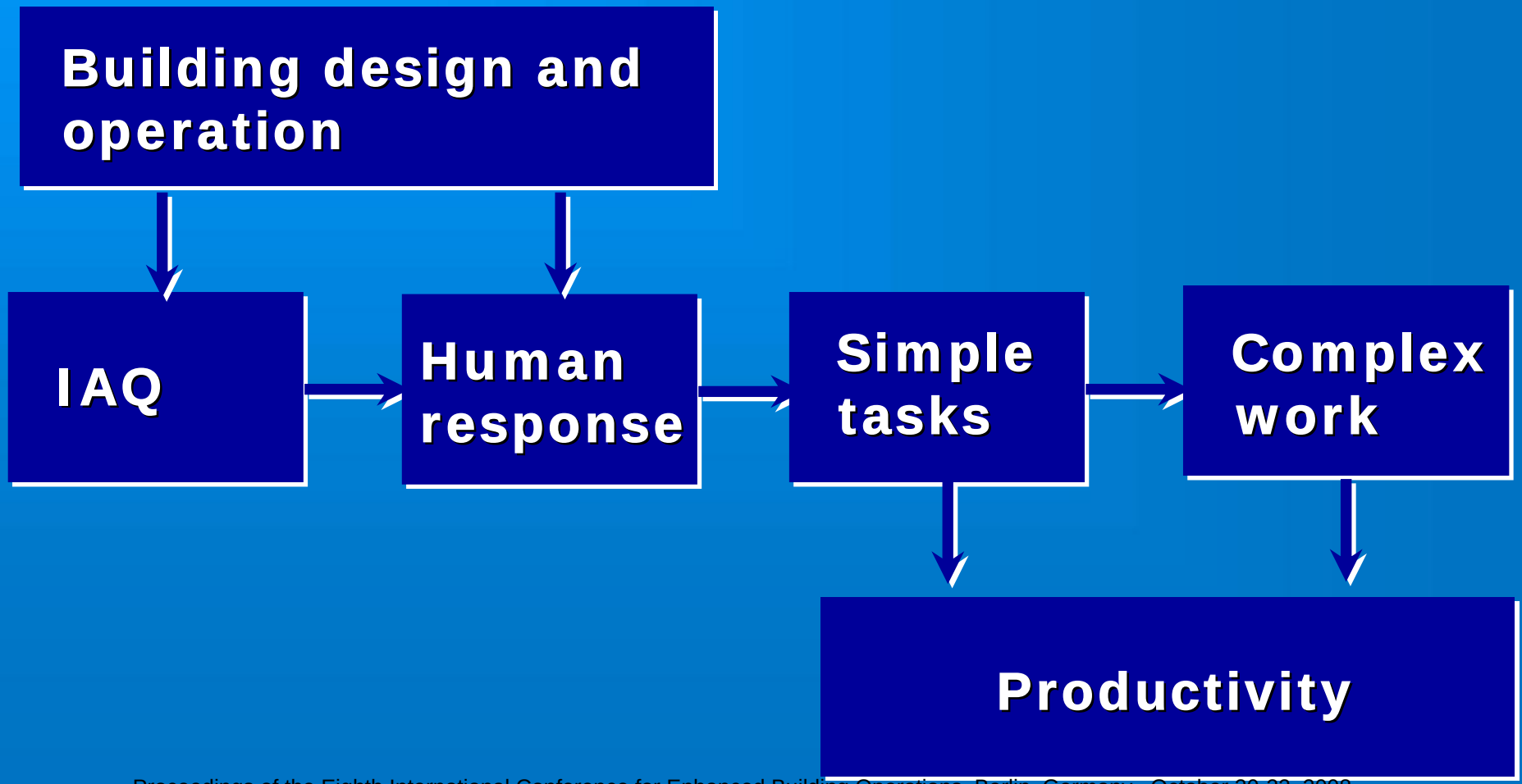
Definitions

- Performance: ability of an individual to perform different mentally and/or physically demanding tasks
- Productivity: a volume measure of output (e.g. performance of individuals, products, services) in relation to input (e.g. costs related to their work)

Performance vs productivity

- Effect on individual performance of reading: reduced by 10%
- Effect on overall productivity: reduced by *only* 5% if reading speed critical for 50% of the working day

Indoor air quality (IAQ), buildings, performance, productivity



Factors affecting performance/productivity

- Economic conditions and external factors
- Management practice
- Training
- Incentives
- Person-jo fit
- Technology
- Individual skill abilities
- Pre-existing health

- Job satisfaction
  - Commitment
    - Creativity
      - Health
- Social cohesion
  - Absenteeism
- Task Performance
  - Staff turnover

Effects of air quality on performance/productivity

- Decreased air quality due to indoor air pollution may induce altered states of arousal which affect work performance directly.
- Decreased air quality may induce symptoms such as headache and difficulty in concentrating which affect mental work directly.
- Decreased air quality may induce symptoms such as sore eyes, dry lips or skin, which constitute a source of distress and a distraction.
- The levels of common indoor air pollutants may have direct effects on mental performance, as they do at toxicologically significant levels.
- The levels of airborne particulates, in particular of allergens such as pollen and other biological material, may induce sub-clinical symptoms of distress which reduce performance.
- Increased odor may cause distress which acts as a distraction and which also alters the perception of the working environment, reducing motivation.
- Decreased indoor air quality through complaints and communication between employees may change attitudes about the employer, reduce motivation and cause distraction which in turn affects work performance.

Labour costs

- Salaries/energy costs = 25-100
- Salaries/maintenance costs = 25-100
- Salaries/rental costs = 2-15
- Salaries/construction costs = 4-40

⇩

Running costs of HVAC <1% of labour costs

⇩

Productivity gains >>> energy & building costs

Life-cycle costs

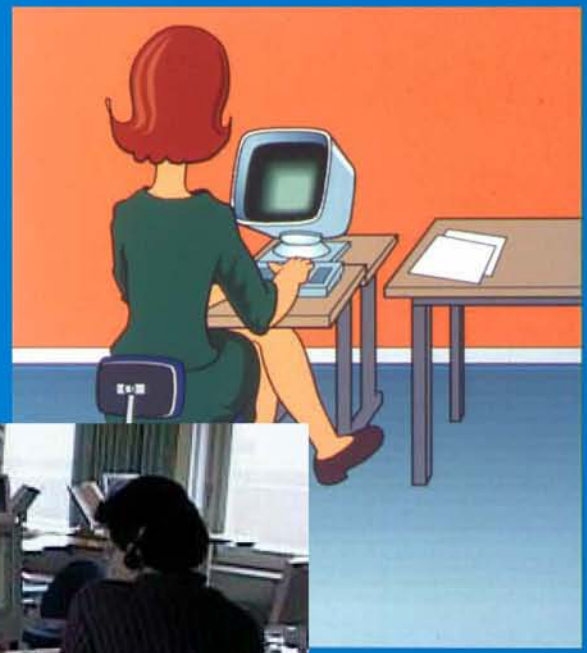
”In a life cycle cost analysis of a building a lost annual productivity of 5% becomes completely dominating”

Impact of indoor air quality on performance of office work

- Laboratory experiments in a simulated office environment
- Intervention field studies in real offices

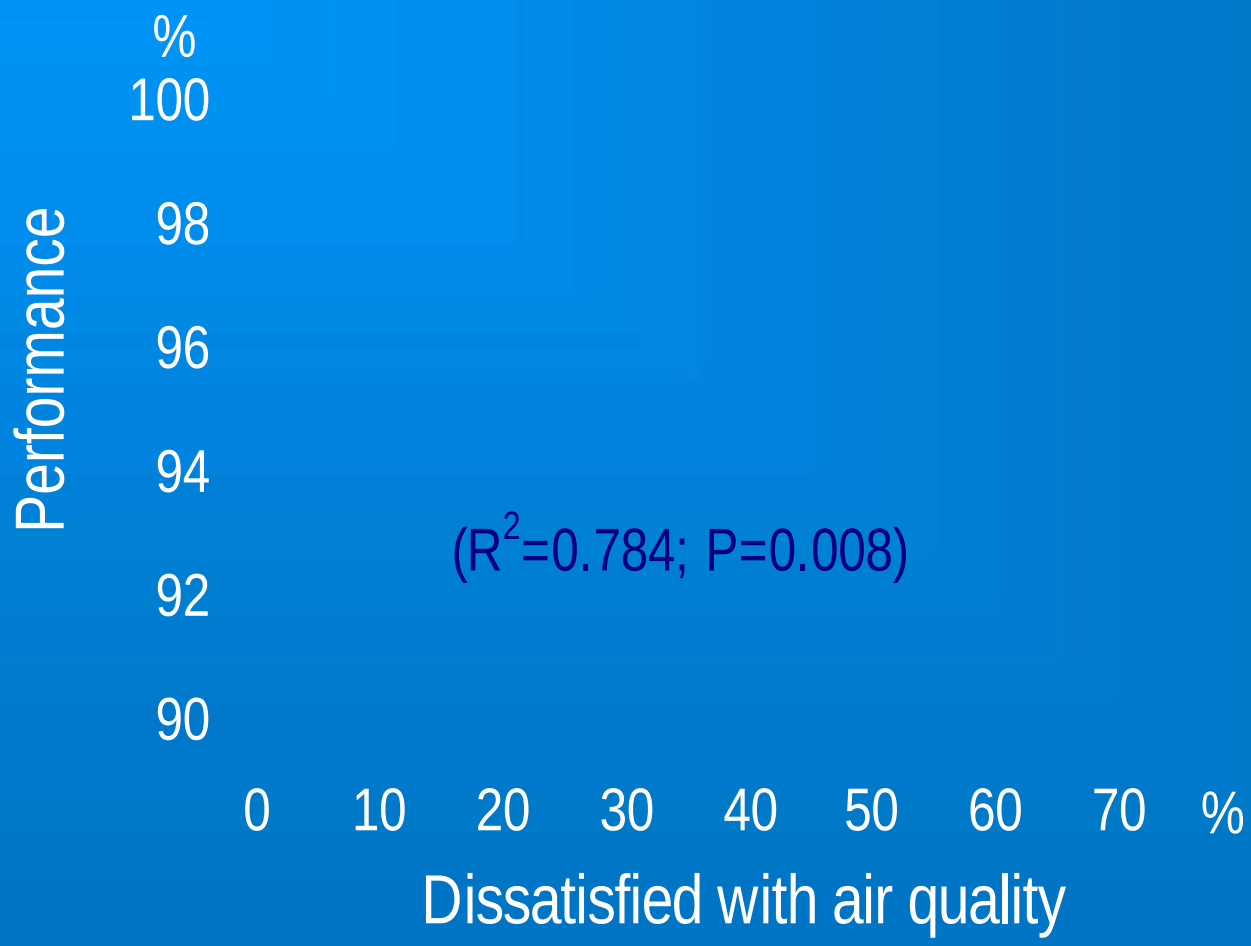
Measurements of perfomance

- Simulated work (typing speed, proof-reading accuracy, arithmetical calculations)

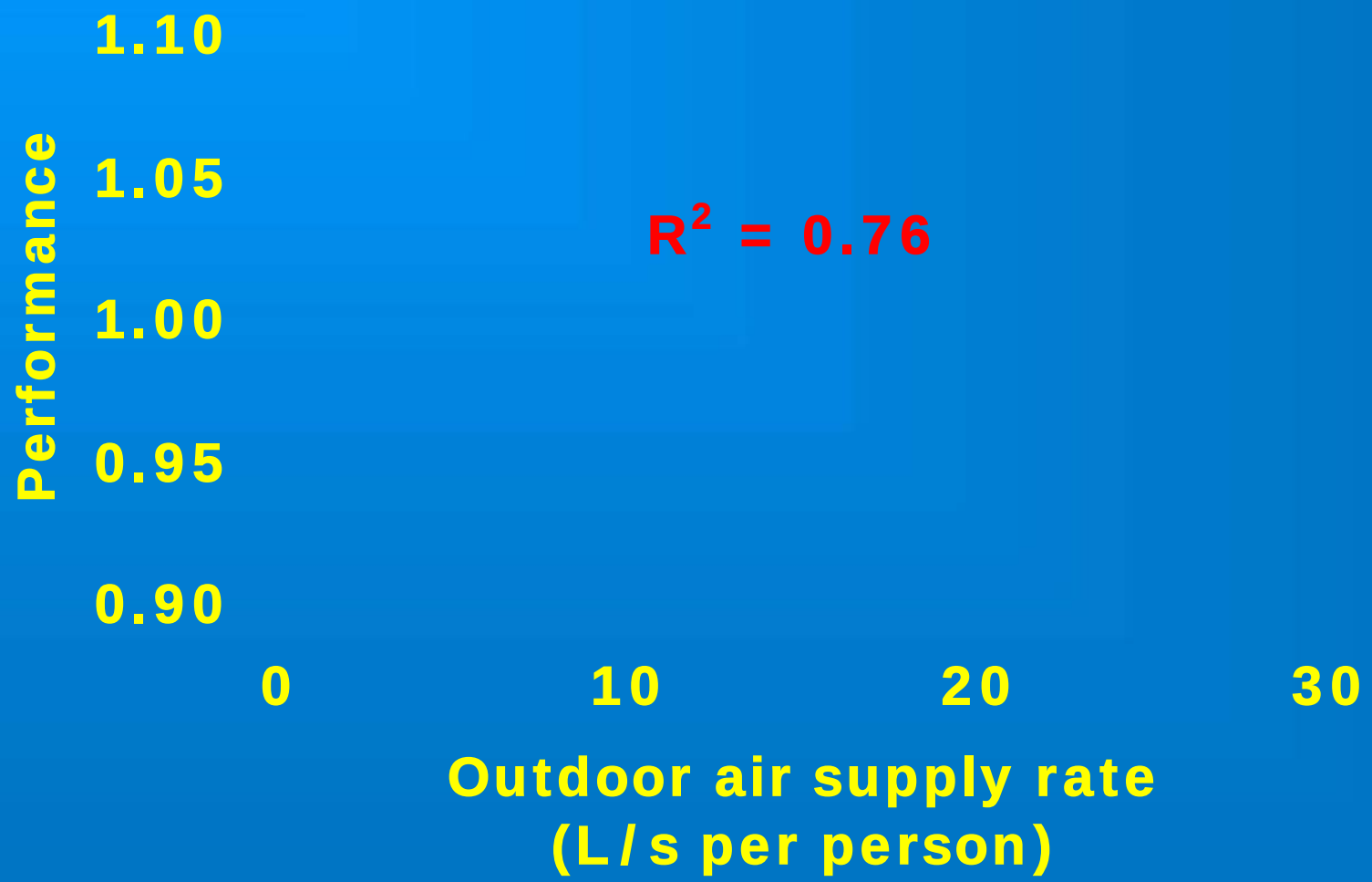


- Existing company measures (talk-time in a call centre)

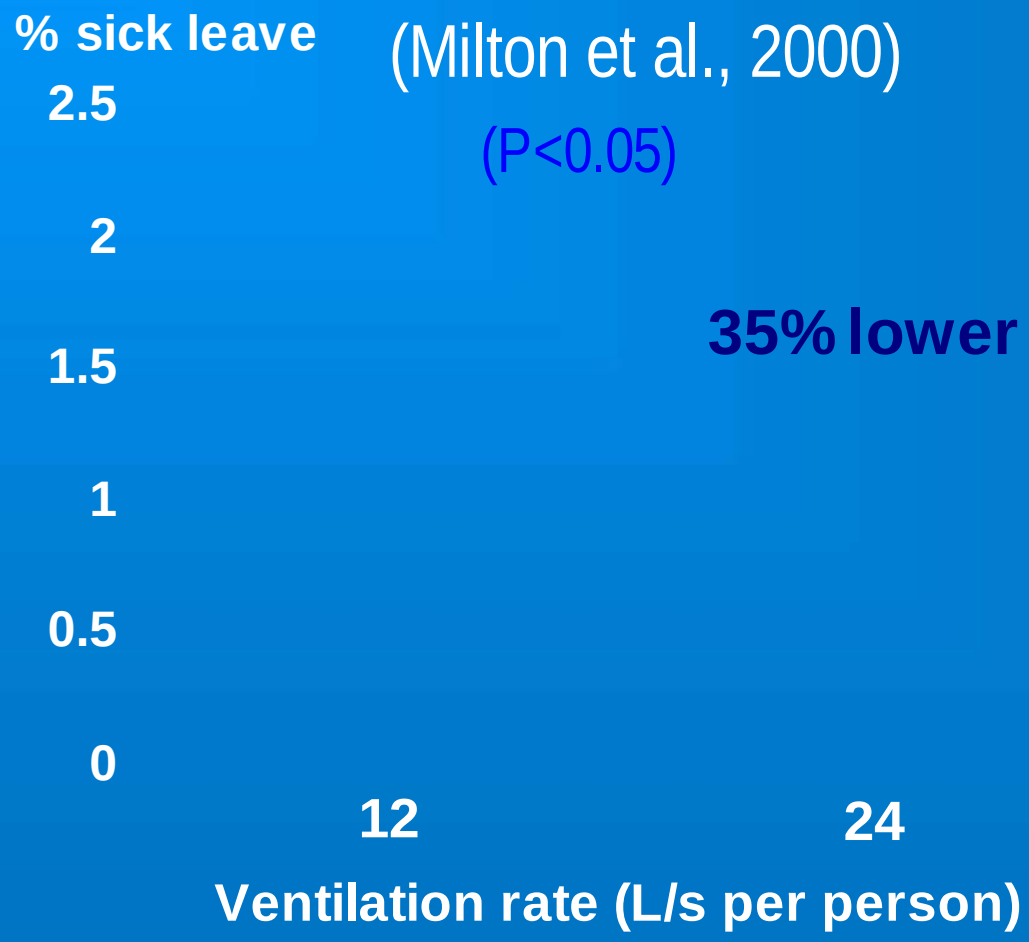
Air quality vs performance



Talk time & ventilation



Increased ventilation reduced sick-leave



Is 5% increase little or much?

- 5% increase in the effectiveness of physical and mental work.
- increased time at work - 25 min/day;
- reduced breaks from work;
- reduced sick leave - 10 days/year;

Economic implications from improved indoor air quality in offices

- The annual benefit of increased productivity due to improved air quality >> the increase in annual energy and maintenance costs
- Estimated pay-back time < 2 year
- Profit: 4-7 times higher than with interest rate at 3.2%

Economic benefits of better IAQ

Owner
occupied
building

Investment

Economic
benefits

Better IEQ

Better productivity
Improved
performance
Less sick leave
Less complaints

Economic benefits as a driving force

Leased building

Building owner

Higher market value of building

Investment

Higher user satisfaction

Better IAQ

Higher rent

Better productivity
Less sick leave
Less complaints

Benefits to employer

Comments

- A growing demand for continuously increasing competence and productivity
- Occupants suffer too often from an inferior indoor environment which reduces productivity and has adverse health effects
- The majority of all working places are in an office-type of environment and the proportion is continuously growing

Impact of indoor air quality on performance of schoolwork

- Intervention field studies in real offices

Measurements of performance

Tasks appropriate to children age, developed in consulation with class teachers

4 languge-based:

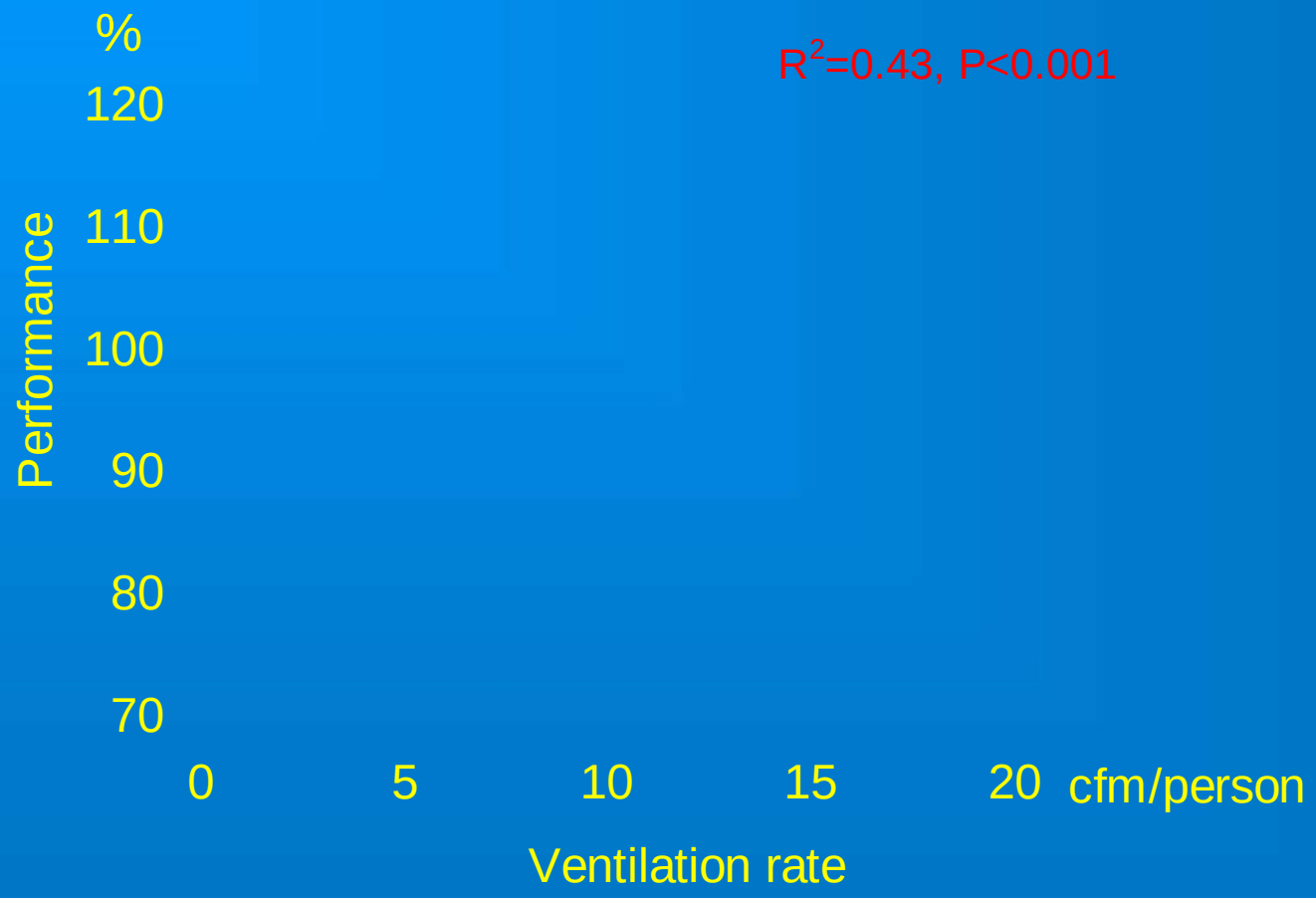
- Acoustic proof-reading
- Reading and comprehension
- Logical reasoning
- Proof-reading

4 numerical:

- Subtraction
- Multiplication
- Number comparison
- Addition

Tasks performed during math and language lessons

Performance of schoolwork as a function of classroom ventilation: speed



Doubling ventilation rate ~14.5% higher performance

Economic implications from improved indoor air quality in schools

- No simulations yet
- 15% ~ ca. 15% more time to solve problems (learn)
- May reduce absenteeism for pupils (parents) and teachers
- May have future consequences for national economy

Comments

- IEQ in classroom plays an important role in learning process, probably as important as teaching materials and methods
- High IEQ should become an urgent educational priority

Sustainable improvement of indoor air quality is required

- 35% of energy in Europe for creating indoor climate
- Improving indoor air quality while decreasing ventilation and saving energy

EPBD 2002 = Energy crisis in 1970s?

- The Directive 2002/91/EC Energy performance of buildings – a measure to improve the energy performance of buildings
- Directive requires that the improvement of energy performance of buildings would be met with respect to indoor climate requirements, so the energy reduction cannot have any negative effect on indoor environment conditions

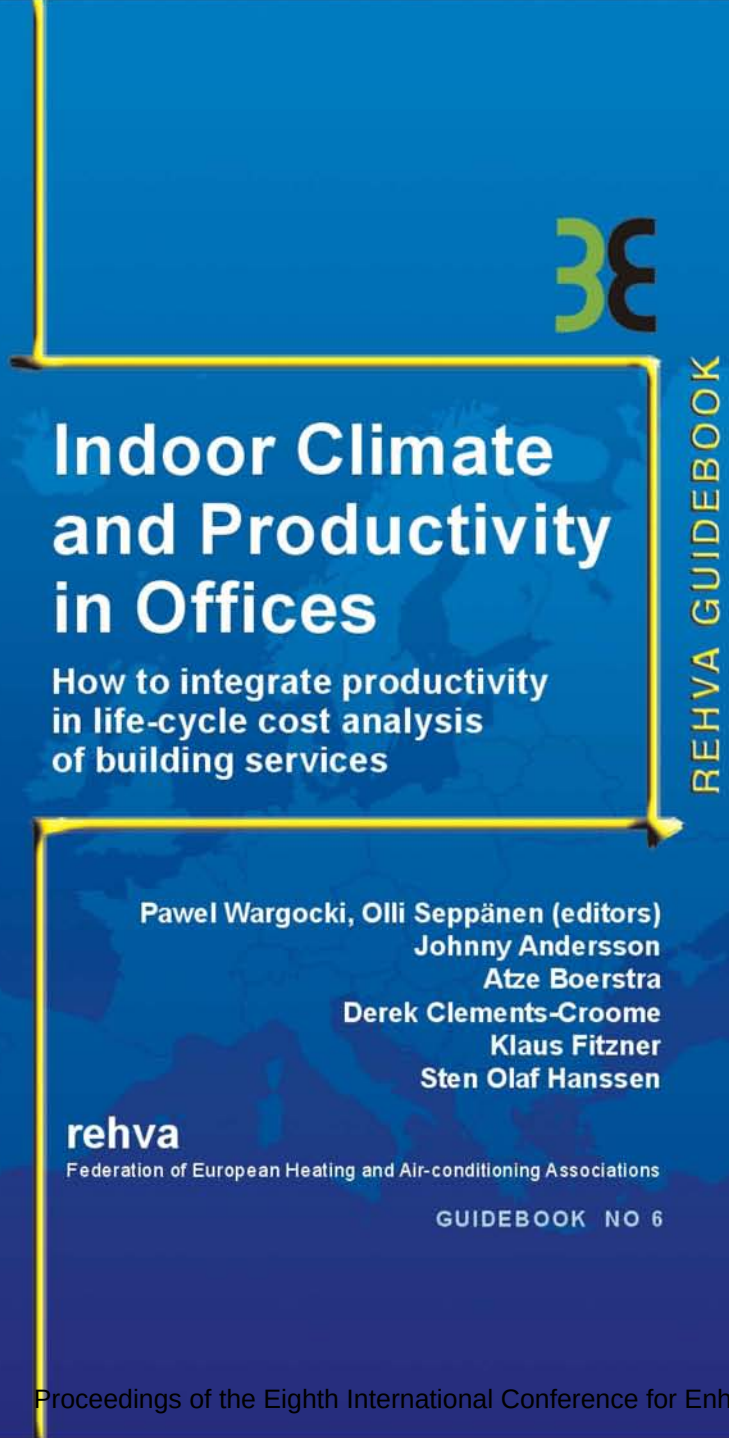
New and existing technologies for improving IAQ are needed

- Reducing indoor pollution sources
- Natural ventilation
- Improving filtration/air cleaning

Summary

- There is growing experimental evidence that indoor air quality affects human performance.
- The present data document the economic benefits of providing indoor air of a higher quality than the minimum prescribed by the present ventilation standards.

Further reading



- Procedure for Life –Cycle-Cost calculations
- Five case studies
- Arguments for good IAQ

Thank you

paw@byg.dtu.dk